Atty Docket No. S-0910-A (formerly RA-1728)

APPENDIX A

Example Of Reaction With Rotation
Reference 1, Chapter 6, Section 6.14.

6.14. REACTION WITH ROTATION

The force of reaction of a jet from a stationary body is given in Sec. 6.8 and from a body in translation in Sec. 6.10. Since Sec. 6.13 develops the equation for the flow through a channel in rotation, we are now ready to consider the force of reaction of a fluid discharged from a rotating body.

A familiar object to illustrate this subject is the rotating lawn sprinkler. In Fig. 6.16 assume that the cross-sectional area of the arms is so large relative to the area of the jets that fluid-friction loss in the arms may be neglected. Water enters at the center, where $r_1 = 0$, so that in Eq. (6.20), $u_1 = 0$. With the sprinkler arms lying in a horizontal plane, $z_1 - z_2 = 0$, and for the jets discharging into the air, p_2 is atmospheric pressure and will be regarded as zero. Since friction is neglected, $h_L = 0$, and if we let $h = p_1/\gamma + v_1^2/2g$, Eq. (6.20) applied to Fig. 6.16 becomes

$$v_2 = \sqrt{2gh + u_2^2} \qquad (6.23)$$

If a_2 denotes the sum of the areas of all the jets (two in the figure shown), then $Q = a_2 v_2$. This shows that the discharge is a function of

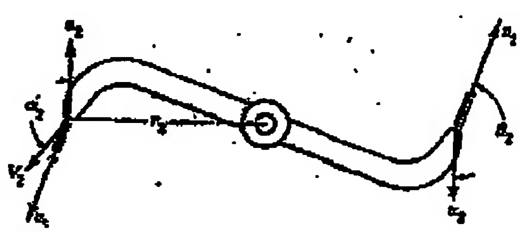

Fig. 6.16

[illegible] The tangential component of the [illegible] velocity of discharge is [illegible] and hence the [illegible] of the force of reaction is

$$[illegible]$$

As the radius is a factor in any rotating body, it is usually better to compute torque rather than a force. In this case the torque is

$$T = F_t r_2 = -\frac{\gamma a_2 r_2}{g} v_2 (u_2 + v_2 \cos \beta_2) \qquad (6.24)$$

The ideal maximum, or runaway, speed is when $T = 0$, and this will be the case when $u_2 = -v_2 \cos \beta_2$ and when $V_2 \cos \alpha_2 = 0$ or $\alpha_2 = 90°$. Because of mechanical friction this condition will never be realized. Of the total power supplied to the sprinkler, the greater part is lost in the kinetic energy of the jets. The total power *developed* by the sprinkler is used in overcoming its own friction. If there were more arms, with larger orifices, so as to discharge more water, there could be a surplus of power which would be useful power delivered. A primitive turbine constructed in this manner was known as Barker's mill.